コンフリクトの解決の過程：鳥取県市瀬集落における災害マネジメントの事例調査

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The Process of Conflict Resolution: A Case Study of Ichinose Disaster Management Conflict, Tottori Prefecture, Japan

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Synopsis

Graph model for conflict resolution, a game theoretic based approach is used to analyze the on going conflict in Ichinose community, Chizu Town, Tottori Prefecture, Japan. The conflict arose when the local company refused to take a possible action for disaster mitigation as ordered by the prefecture government. Two different phases of this conflict are analyzed in order to understand why the confrontation occurred and how the disputes evolved over time. The equilibria help to manifest the possible solution scenario in this game. It is recommended that the effective communication, player's capability are essential factors which can help to move the situation in a better way.

Keywords: Graph model; conflict; equilibria

1. Introduction

Basically conflicts arise when different stakeholders are not able to come a mutual acceptance point. Pruitt and Rubin (1986) defined the conflict in a holistic way, "a perceived divergence of interests, or a belief that the parties' current aspirations cannot be achieved simultaneously.'' Most of the conflict scholars are in opinion that process is very important to understand the roots of conflict and its possible resolution. The entire process of this concerned dispute has been analytically described using GMCR (Graph Model for Conflict Resolution) model. Basically this model is based on game theory which is further extended by Fraser and Hipel. In this model instead of cardinal utility, decision maker's ordinal preference can be ranked from most preferred to least preferred. The model assumes that all preferences are transitive. It gives analytical insights to understand the problems within which the possible strategic interaction among the decision makers (DMs) can be systematically analyzed in order to ascertain the possible compromise resolutions, or equlibria.

2. Modeling

We propose to apply the GMCR to formulate and analyze the static structure of a real world conflict. The major advantage of this model is its ease with which to model the interplay structure among multiple players who have their own effective strategies (called "moves") from a particular outcome and who can only order possible outcomes in terms of preference.

The GMCR (Fang et al, 1993) is founded upon a mathematical framework utilizing concepts from graph theory, set theory and logical reasoning. It represents a conflict as moving from a state to another state (the vertices of a graph) via transmissions (the arcs of the graph) controlled by the decision makers. Mathematically this multi-player conflict game can be formulated in the following way:

Let N= {1, 2, …, n} be the set of players and K= $\{K_1, K_2, \ldots, K_u\}$ be the set of states of the conflict and n-tuple $\{D_i\}$ (i =1, 2…, n) as the set of directed graph that $D_i = (K, V_i)$. The set of arcs V_i means player i's possible move between states. Let $k_l k_m$ be the arc from the state k_l to the state k_m. If $k_l k_m \in V_i$, it implies that player i can move from the state k_l to the state k_m, unilaterally. The payoff function P_i specifies the player i's preference order for states. If $P_i(k_l)>P_i(k_m)$, player i prefers the state k_l to the state k_m. The Graph for Conflict Resolution (GMCR) is presented by 4 –tuple {N, K, V, P}, where, $N=\{1, 2, \ldots, n\}$, $K=\{1, 2, \ldots, k\}$, $V=\{V_1, V_2, \ldots, V_n\}$ and $P=\{P_i \setminus i \in N\}$.

One advantage of graph model over more traditional game theoretical approaches is that it can represent irreversible moves. In such cases, a decision maker can unilaterally move from state k to state q but not from q to k. DM i 's graph can be represented by i's reachability matrix, R_i, which displays the unilateral moves available to DM i from each state. For $i \in N, R_i$ is the u x u matrix defined by

$$R_i(k,q)=\begin{cases} 1 \text{ if DM } i \text{ can move (in one step)} \\ \text{from state k to state q} \\ 0 \text{ otherwise} \end{cases} \quad (1)$$

Where $k \neq q$, and by convention $R_i(k,k)=0$

In GMCR, players can make a transition of conflicts. When a player does not have an incentive to move from a particular state, the state is called stable for the player, the state is called equilibrium. In this paper two solution concepts are employed.

Nash Stability

The state K is Nash stable for player i iff i cannot improve its payoff by changing his own strategies. In the other words,

$$S_i^+(k)=\{\varnothing\}. \quad (2)$$

Sequential Stability

The state k is sequentially stable for player i iff for every $k_1 \in S_i^+(k)$, there exists $k_2 \in S_j^+(k_1)$ with $P_i(k)>P_i(k_2)$.

3. Background of the Conflict

In the case of the Ichinose community (Chizu, Tottori, Japan) disaster mitigation conflict, the confrontation evolved when the local quarry company refused to take what seemed to be a possible action for disaster mitigation work ordered by the local government. The authors have found that the conflict is classified in two phases. In the first phase（1985）, there were only two players, i.e., local government and the local company. But in January 2002, a large-scale landslide occurred and the local community became alert and more active. For disaster mitigation work from this time they also started to take a part of this game. Thus in the second phase (2002) of this conflict, there were three players, i.e., local government, local company and local community. We elaborate on the above points more in the following.

It is a very small community having 32 households. Due to potential land resources, the local government planned to explore rock resources from this area for construction of roads and other civil work. Thus, the rock quarry became a resource base for local development. Around 30 years back one local quarry company (Hisamoto Company) entered in this area in support of the local government and this contract agreement intended to include safety measures from the company side. In 2002 after the devastated landslide, the local government ordered to the Hisamoto Company to stop the rock quarry and also ordered to clear the rocks and debris from the site. But the company refused to do so, probably because their quarry work had been officially registered by the local government and also their work continuously monitored by them. After the disaster, the local people were not ready to move from their site. So they asked the local government to clear the rocks and debris from the site and also to operate an early warning system (EWS). Since the local company was not ready to do, so the local government took a legally assured administrative step. The history of the conflict is described here in different time periods (Table 1).

Table 1 Chronology of the Conflict

Year	Occurrence	Action taken
1985	On March 23, a landslide occurred and the debris felt into the river Sendai (43,000 m^3).	**Notification by the local government** • Clearance of the pilled up waste from the river. • Taking emergency measures.
1996	Again on 27 September another landslide occurred and the debris felt into the river Sendai (30,000 m^3) and a large crack was discovered along the ridge.	**Notification by the local government** • Clearance of the pilled up waste from the river. • Order for emergency measures. • Notification for suspension of rock quarry operation.
1998	On September 24 and 25, due to heavy rainfall another landslide occurred at the quarry site and the earth felt in to the Sendai river.	**Notification by the local government** Clearance of the landslide (securing of a pocket) and construction of a deposit pond.
	Again on October 25, the earth (50,000 m^3) was pilled up at the quarry site and was crumbled due to typhoon (1825 mm ppt) and felt into the river Sendai. Six houses in Ichinose community were affected very badly. National highway no. 53 and part of the tunnel was blocked. The JR line and few quarrying equipments of the Hisamoto Company were also washed away.	The local government rebuilt the riverbed and the company did the clearance of the disposal earth.
2002	On January 25, a big landslide occurred and the Piled up waste was dumped at the waste treatment site. The river flow was blocked due to landslide (dam formation).	The local government ordered to the Hisamoto company to remove the rocks and debris from the site. But Hisamoto Company refused to do this job and thus local government ordered to the Hisamoto company for reimbursement of expenses incurred in the restoration process in accordance with river loss. The claimed amount was 1,736,604,804 yen and on March 12, the property of the company was totally confiscated.
2004	Owing to the heavy rains caused by typhoon no. 21 on 29th to 30th September the Sendai river flooded. Further more due to the heavy rains, the left side cliff of the mountain collapsed and soil and rocks felt into the riverbed, which resulted in dam formation. Because of this ten houses and the community center were completely flooded and the JR line was closed by for one and half days and mud and rubbish were accumulated on the tracks.	Temporary shelters have been arranged by the local government and they also established a disaster mitigation office at Ichinose community to monitor the disaster mitigation work and operate the early warning system. On June 20, the new governor was elected.
2005		Monitoring the Early Warning System (EWS) by the local government.

4. Model of the Conflict

We divide the whole process of the conflict into two phases plus the instantaneous period of change in structure that is interpreted to have occurred between the end of the first phase and the start of the second phase. To model the static structures of both the first and second phases, GMCR is used as follows.

4.1 Two phases of the conflict

(1) Phase I: Decision makers and their relative preferences

This conflict is modeled by use of GMCR II. In March 1985, the start of phase I and the point in time for which the modeling and analysis is done. The two players have identified in this conflict i.e., the local company and the local government. The local government consists of the prefecture government and the town office. In that time Player's and their relative options and the Status Quo state are listed below (Table 2). Mathematically there are total 32 (2^5=32) possible states, but after removing all the infeasible states there are 14 feasible states in total (Table 3). Some states are infeasible because they are mutually exclusive. In Tables 2 and 3 ,'Y' means 'Yes' and indicates that the option has been taken and 'N' means 'No', indicates that the player has been rejected that option. The local company's ranking states from most preferred to least preferred was $5 \succ 1 \succ 13 \succ 9 \succ 3 \succ 11 \succ 7 \succ 6 \succ 2 \succ 14 \succ 10 \succ 4 \succ 12 \succ 8$ and the local government's preference order was $10 \succ 8 \succ 9 \succ 7 \succ 14 \succ 12 \succ 13 \succ 11 \succ 2 \succ 1 \succ 6 \succ 4 \succ 5 \succ 3$ The desirability of each state of each player is structured in the following way. A positive number means that a player prefers that option is taken, and negative number is that a player does not prefer that the option is taken. Players have the following options.

Local company's desirability

- Local company wants to quarry rock deposit. (1)
- Local company does not want to operate and maintain the EWS. (-2)
- Local government can allow them for rock dumping at the site. (3)
- Local government can operate and maintain the EWS. (4)
- Local company does not want to monitor their work by the local government. (-5)

Local government's desirability

- Local company can quarry rock deposit and dump at another site. (1)
- Local company can operate and maintain the EWS. (2)
- Local government can allow the company for rock dumping at the site. (3)
- Local government does not want to operate and maintain the EWS. (- 4)
- Local government wants to monitor the local company's work. (5)

Here we obtained only one equilibrium, i.,e, state 9 (both Nash equilibrium and Sequential equilibrium) which was also the Status Quo state at that time. Graph model helps to describe the actual outcome as equilibrium in this game. It seems that though the local government suspended local company's quarry work for a while, but again they gave approval to continue the rock quarry work. But the company was not ready to take the proper measures for disaster mitigation work ordered by the local government. Under this condition, the agreement was not stable and local government also did not force their power to settle down the agreement. Thus the delay of the concrete agreement made the status quo state stagnant (modeled as a stable state). Neither the local company nor the local government had potential improvement from the status quo state. But on 25thJanuary 2002, a large scale landslide occurred and this natural disaster accidentally triggered a social shock which forced the game to move on to another phase of this conflict. We interpret that in this instantaneous period some structural change has occurred.

(2) Phase II

The second phase of the conflict has started on 25th January, 2002. At that time, local community became a player in this game and thus the different issues and sub issues changed the structure of the game. Player and their options and the Status Quo state are listed below (Table 4). The same option representation of a state is presented by indicating 'Y' and 'N', where 'Y' indicates yes, the option is taken by decision maker and 'N' means 'No' that is the option is not taken. While'–' signifies either 'Y'or 'N'. Here the strategy means choice of player's options to invoke. States are defined as the combination of player's strategy. In this conflict, there are total 512 states (2^9=512). But many of the states are not feasible for actual conflict for different reasons. For example, the local community has two options, to stay in the same village with disaster preparedness and shifting the village with public facilities. Both are mutually exclusive, so they are infeasible options. But, in case of the local government, out of four options, two options, i.e., rocks and debris clearance from the site and operate and maintain the EWS, both of which are mutually exclusive for the local company. This may be possible with coordination of both players. So, in this case it is regarded as a feasible state for both players. After removing the infeasible options, a total of 18 states have been identified for this conflict (Table 5). Player's ranking of states from most preferred to least preferred are as below:

Local community:

$13 \succ 11 \succ 12 \succ 17 \succ 10 \succ 5 \succ 3 \succ 4 \succ 15 \succ 2 \succ 9 \succ 7 \succ 8 \succ 16 \succ 6 \succ 14 \succ 18 \succ 1$

Local company:

$1 \succ 10 \succ 2 \succ 6 \succ 12 \succ 4 \succ 8 \succ 11 \succ 3 \succ 7 \succ 13 \succ 5 \succ 9 \succ 17 \succ 15 \succ 16 \succ 14 \succ 18$

Local government

$18 \succ 1 \succ 13 \succ 5 \succ 9 \succ 11 \succ 3 \succ 7 \succ 12 \succ 4 \succ 8 \succ 17 \succ 15 \succ 16 \succ 14 \succ 10 \succ 2 \succ 6$

Table 2 Players and their options, March 1985

Players and their options	**Status Quo State**
Local company	
1.Rock quarry and dumping at the site	Y
2.Operate and maintain the EWS	N
Local government	
3.Allowing for rock dumping by local company	Y
4.Operate and maintain the EWS	N
5.Monitoring	Y

Table 3 Feasible states of the conflict in phase I

Option \ States		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Local company	1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	2	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y
Local government	3	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y
	4	N	N	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y
	5	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y

Table 4 Players and their options, January, 2002 in phase II

Players and their options	Status Quo State
Local community	
1.To stay in the same village with disaster preparedness	Y
2 Shifting the village with public facilities	N
Local company	
3.Rocks and debris clearance from the site	N
4.Operate and maintain the EWS	N
5. Appeal to the national government	Y
Local government	
6.Assisting the local community for shifting the village	N
7.Order of rocks and debris clearance from the site	Y
8.Operate and maintain the EWS	N
9. Waiting for the national government's judgment	Y

Table 5: Feasible states of the conflict in phase II

Options \ States		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Local community	1	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-
	2	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	-
Local company	3	N	N	Y	N	Y	N	Y	N	Y	N	Y	N	Y	N	N	N	N	-
	4	N	N	N	Y	Y	N	N	Y	Y	N	N	Y	Y	N	N	N	N	-
	5	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
Local government	6	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	-
	7	N	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	N	Y	N	Y	-
	8	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	-
	9	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y

Table 6: Option prioritizing

Local community	Local company	Local government
-6	-9	3 IFF 1
7	-3	4 IFF 1
8	-4	9
3	5	6
4	6	2
1	2	-1
-2	-1	7
9 IF -3,- 4	7	8
-5	8	-5

The player's preferences over the states defined by the combination of options can be ranked by using option prioritizing (Table 6).The desirability state of each player is assumed as follows.

Local community's desirability

- Local community intends to stay in the same village with disaster preparedness. (1)
- Local community does not want to shift from their place. (-2)
- Local company should clear the rocks and debris from the site. (3)
- Local company should operate and maintain the EWS.(4)
- Local company should not appeal to the national government. (-5)
- Local government should not assist the local community to shift the village. (-6)
- Local government should clear the rocks and debris from the site. (7)
- Local government can operate and maintain the EWS. (8)
- Local government wants to wait for the national government's judgment (9 IF -3,-4)

Local company's desirability

- Local community does not intend to stay in the same village with disaster preparedness. (-1)
- Local community wants to shift from their place. (2)
- Local company does not want to clear the rocks and debris from the site. (-3)
- Local company does not want to operate and maintain the EWS. (-4)
- If local government will appeal to the national government's judgment, then they will file the case. (5)
- Local government can help the local community for shifting the village. (6)
- Local government can clear the rocks and debris from the site (7)
- Local government can operate and maintain the EWS (8)
- Local government should not appeal to the national government (-9)

Local government's desirability

- Local community does not intend to stay in the same village with disaster preparedness. (-1)
- Local community can shift their village. (2)
- Local company can clear the rocks and debris from the site. (3 IFF 1)
- Local company can operate and maintain the EWS. (4 IFF 1)
- Local company should not file the case. (-5)
- Local government can assist the local community to shift their village. (6)
- Local government can clear the rocks and debris from the site. (7)
- Local government can operate and monitor the EWS. (8)
- If the local company does not cooperate, then they can wait for national government's judgment. (9)

5. Stability analysis and solution concepts

To understand the behavior of each player in this conflict situation stability analysis has been conducted. In this analysis, the Status Quo state is not to appear as an equilibrium state. States 1, 11, 12, 13, 17 and 18 are the possible equilibria in this conflict. Among all the equilibria states 1, 11, 12 and 13 are the co-operative equilibria and states 17 and 18 are the non co-operative equilibria. Practically the game has ended up at this stage (as of the end of year 2005) as a non-cooperative way (in the form of adversary positions taken by both the local government and local company). Since the local company was reluctant to cooperate with local government thus the local government took the legal step against the local company. The states 17 and 18 are the final outcomes of this conflict (though the local government did not start the EWS at this stage). Since the local community was not ready to move from their location, so equilibrium 1 was found to be not a possible solution of this game. The game did not proceed in a cooperative way perhaps due to mistrust and miss communication among the players. From the figure 3, we can trace out the irreversible moves and common moves. From the non cooperative equilibria 17 and 18, none of the players had potentiality to move a better solution. It is assume that neither local company nor local government had the appropriate information of the other side. Other wise, a new proposal either from local company or local government side could bring the conflict in state 11, 12 or 13 or this can also change the structure of the game.

6. Conclusions

As referred to in the above, we can qualitatively analyze how the structure of the conflict has changed over time. Our interpretation is that the intervening social shock caused by the repeated landslides, have triggered the contextual shift in the development of the conflict. We may also infer that some political climate change such as a new governor being elected and coming in office could have also contributed to such a quantum jump in the structure of the conflict. The conflict has been escalated at the second phase of this game and there remained no further scope to deescalate the conflict. In this conflict, the communication was stopped. The community was not much aware about the risk of quarry work. Thus, an effective communication platform was very much needed. The structure of the conflict can be altered by intervention of third party. They can help to bring all the parties in a common table to accept the responsibility for concessions and thus the whole process can be turned towards a resolution.

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コンフリクトの解決の過程：鳥取県市瀬集落における災害マネジメントの事例調査

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要旨

ゲーム理論に基づいたコンフリクト解決のグラフモデルを、鳥取県智頭町市瀬集落において進行中のコンフリクト分析に適用した。本コンフリクトは、県が災害緩和のための行動をとるよう命じたのに対して、地域企業がこれを拒絶したときに生じた。対立が生じた原因と、議論の進展の過程を理解するためにこのコンフリクトを２段階に分けて分析した。得られた均衡解は、本ゲームにおいて可能な解決シナリオを明示するのに有用である。効果的なコミュニケーションとプレイヤーの能力が、状況を改善するために不可欠の要因であることが示された。

キーワード: グラフモデル，コンフリクト，均衡